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STUDIES ON THE BIOLOGY AND CONTROL OF CHIGGERS.

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INTRODUCTION.

Notwithstanding the obvious economic importance of chiggers, and an almost universal acquaintance with their injury, little has been done in the past to ascertain their habits in nature or to find efficient methods for their control. Because of these facts the writer decided early in the season of 1919, with the approval of Dr. L. O. Howard, Chief of the Bureau of Entomology, to begin a series of experiments and observations on their biology and control. The work was started in June of that year and continued until the fall of 1920. For various reasons it was thought advisable to discontinue the work then for some time, hence the results thus far obtained have been prepared for publication. It is the expectation of the writer, in the near future, not only to complete the life history for at least one of our species, but to give a synopsis of the taxonomy and distribution of the species occurring in the United States.

SPECIES CONCERNED.

Years ago C. V. Riley (*10*)[1] described from this country ("southwestern States") two chigger species under the familiar names of

[1] Reference is made by number (italic) in parentheses to "literature cited," page 19.

Leptus americanus and *Leptus irritans*. Although these names have been used frequently in American literature dealing with economic entomology, and the figures of Riley's two species often copied, the present writer is bound to confess that after studying carefully Riley's descriptions and figures and some of his microscope slides (types?) he has been unable to correlate either *americanus* or *irritans* with the two species with which he is familiar. Further than this, it can now be fairly definitely stated that *americanus* is not a species of Trombidiidae at all, but is rather a species of the family Erythraeidae, a group to which the genus Leptus really belongs, as Riley's figure clearly shows. *Leptus irritans* is the larva of a species of Trombidiidae, but the characters given by Riley are not even of generic value; hence it appears that it will never be known certainly what species his *irritans* is.

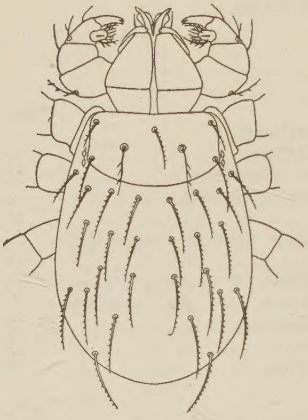

FIG. 1.—Dorsal view of an American chigger (legs omitted), X 150. This drawing was made from specimens in the University of Minnesota collection, which were taken at Lake Minnetonka, Minn.

In New Jersey, Maryland, the District of Columbia, Virginia, and southeastern Iowa there is apparently a single chigger species. The writer has examined many specimens from these sections and finds that they are all the same.

In the northern and western part of the United States there is another very closely related species which has the body shaped exactly like the first mentioned but has more dorsal spines on the abdomen, and fewer branches or barbs on the palpal setæ. This is the species studied by C. W. Howard (*6*). Specimens have been examined from Minnesota and Kansas.

NOTES ON SEASONAL HISTORY.

Chiggers are especially pests of the summer months, as has long been known, but the period of their activity has not been known, even relatively. During the year 1919, at Washington, D. C., the date of the first record of larvæ attaching themselves to man was July 2, and by July 17 larvæ were present in great abundance. On the latter date the writer was severely attacked. During the remainder of July and the whole of August the chigger larvæ continued in great abundance, and almost daily records of their attacks were obtained. In September the attacks were much less severe, yet continued. On September 22 several larvæ attached themselves to man at Chesapeake Beach, Md. No records for the northern part of the United States of chigger attacks in October have been brought to

the writer's attention, but some of the larvæ are probably active during this month.

During the season of 1920 the chiggers were first noted in southeastern Iowa on June 24, when several attached themselves at Keosauqua, where they were present in the State park.

How chiggers pass the late fall and winter is not known, and will not be known until more work is done on the life history of the species and something is known of the nymphal and adult instars.

LOCAL DISTRIBUTION.

Investigations of the last year and a half have thrown much light upon the local distribution of our chiggers, which in turn may furnish the clue for locating their natural hosts and thereby give us an opportunity to rear the larvæ to maturity.

Around Washington, D. C., the chiggers usually have been encountered where there was a heavy growth of wild brush or blackberries. They are not found in cultivated fields or where the ground is bare or in well-kept parks and lawns. Usually they are absent from meadows and from weed patches unless some kind of growth of canes or shrubbery is present. They are always encountered to some extent in woodlands, but are present in great numbers only where there is a considerable growth of underbrush.

In the State of Iowa the chiggers have an even more interesting distribution. Here whole counties in the northern part of the State are apparently free from them notwithstanding that conditions for them seem ideal. The writer has collected mites for years about Ames, Iowa, and on many occasions has made special trips in search of chiggers, but has never found a single specimen in this locality. Yet the town of Ames is almost surrounded by woods and hemmed in by two creeks, and there are situations almost exactly like those along the lower Des Moines River, where chiggers are abundant.

Judging from the records up to date, chiggers are only present along the main river courses in the south-central, southeastern, and eastern parts of Iowa. From the city of Des Moines north along the Des Moines River the writer has not been able to collect specimens, although the attempt was made in several localities.

The environment found necessary in Iowa is the same as that in Virginia or Maryland, since nearly all the land is given over to cultivation; however, chiggers are found only in a relatively small area, while in the East they are found over very extensive ones.

HABITS OF UNATTACHED LARVÆ.

The belief has been almost universal that chiggers in this country are found in the grass. Observations have failed to confirm this theory. It was found that our northeastern species occurs almost

exclusively at or near the surface of the soil. In this respect the larvæ differ from tick larvæ, which climb up on vegetation of various kinds and remain in wait for a host. People frequently get chiggers when they go into the grass, but our eastern species approaches from the ground. The mites can be found in surface scrapings, but repeated attempts to recover them from growing vegetation have failed.[2]

If chiggers attack man almost solely from the ground the question may be asked, How are we to account for attachments around the waist, under the armpits, and about the eyes? Again, observations show that chigger attacks are seldom made above the waistline, unless the clothes are quite loose around the waist, or the individual has been sitting or reclining on the ground. When one simply walks through a chigger-infested region, the larvæ are first found about the feet and ankles. Here they can be seen with a hand lens. They run with great rapidity, so fast in fact that it is very hard to catch them. From the ankles they spread upward, few as a rule attaching here, unless the clothing is tight; if so, many may attach. As they pass upward many of the larvæ either stop themselves or are stopped at the garters, if these are worn below the knees. If they pass the garters large numbers will attach in the space under the knees. Those that pass the knees usually go as far as the waistline before they attach.

Two factors are of importance in regard to the localization of chigger attachment—the tightness of the clothing at certain parts of the body and the thickness of the skin. The garters around the legs and the belt around the waist act as semieffective barriers. For a great many minutes, sometimes for a few hours, the larvæ run over the skin hunting a favorable place of attachment. These rapidly moving larvæ are halted by the garter or belt pressure, and after struggling some time either to pass through the mesh of the clothing at these points or to extricate themselves may attach without further search. The writer has watched these active larvæ on the skin of man before and after attachment and finds that tight clothing does not aid them in "digging in" by furnishing a fulcrum, as has been supposed. In fact, it was found experimentally that chiggers do not "dig in," as has been so frequently stated, but remain attached externally like a tick does.

The thickness of the skin is of great importance in localizing chigger attachments. Where the skin is unusually thick the larvæ attach with great difficulty or not at all; and of those that do attach

[2] Dr. F. H. Chittenden has reported to the writer chigger attacks coming from overhead vegetation. The writer has never experienced such attacks, and up to the time of the preparation of this paper none had been reported to him. It may be that a second species, which is relatively rare, occurs in this vicinity, as Dr. Chittenden suggests.

many can not remain attached during the body movements of the host or are not able to reach the lymph supply of the true skin and engorge. Of the thousands of chigger attachments observed by the writer, not a single one was found on the calloused parts of the hands or feet.

HOSTS.

It was the belief of earlier entomologists that chiggers lived upon the juices of plants. That C. V. Riley shared this common belief is evident from the following statement (*10*) which he made in regard to one of his species:

> The normal food * * * must, apparently, consist of the juices of plants and the love of blood proves ruinous to those individuals who get a chance to indulge it.

When it was learned by actual rearing experiments that several of the species of Trombidiidae were normally parasitic on terrestrial tracheates, this older theory was dropped, and it was commonly assumed, and frequently stated, that the chigger larvæ were normally parasitic on insects and closely related invertebrates. This belief was equally shared by the mite specialist and the general entomologist; but that the chigger larvæ could be normally parasitic on vertebrates was never suspected; in fact, the references to their "death feast" on man or domestic animals continued as numerous as before.

When the writer began, in the summer of 1919, his search for the natural host of the species occurring in Virginia and Maryland, he collected all insects found parasitized with trombidiid larvæ. These larvæ were examined to see if any of them belonged to the species attacking man, or were in fact true chiggers. Although many insects and other tracheates were found parasitized, in no instance did these parasitic larvæ prove to be the species attacking man.

Not satisfied with this method of investigation, another was instituted. On some vacant lots that had grown up to a considerable extent in blackberries and which were very heavily infested with chiggers (over a hundred attached in less than two hours), insects of all kinds were collected. There were hundreds of them and scores of species.

These insects were taken to the laboratory and examined both alive and after killing in cyanide bottles, and in no case was a single specimen of our eastern chigger found. The sweepings and other collections were so thorough that this observation convinced the writer that the chigger found in the vicinity of Washington is not a normal parasite on terrestrial tracheates that live above the ground.

Although never believing in the old vegetarian theory of the earlier entomologists, the writer decided to give this theory a test. First a minute examination was made of the blackberry plants, including all parts both in and above the ground. Not a single chigger was found on them. Then the examination was extended to the other plants growing on the vacant lots—goldenrod, several grasses, and a number of common weeds. Each plant species was taken by itself, specimens were pulled up, shaken over white paper, taken to the laboratory, and even examined in parts with the microscope. After several days of fruitless attempts to locate the larvæ feeding on plants the work was stopped, for evidently they could not have been feeding normally on these, or at least a few of their enormous numbers would have been encountered.

About this time there appeared in this country the extensive paper by Drs. T. Kitashima and M. Miyajima (*7*) entitled, "Studien ueber die Tsutsugamushi-krankheit," in which is given, among other things, a summary of the work on the life history and habits of the Japanese chigger, *Trombicula coarctata* Berlese (*1*). These writers claimed to have reared this chigger mite from field mice and to have established the fact that it was normally parasitic on the same. A few days later Dr. Miyajima, who happened to be visiting in this country, called at the Bureau of Entomology while in Washington. During his stay he reiterated his statement that the Japanese chigger was normally parasitic on field mice and also said he believed that it normally parasitized various other mammals.

Following the conference with Dr. Miyajima, it was decided at once to investigate the small rodents which were known to exist in the vicinity and on the ground of the infested lots. A dozen traps were procured and trapping began with these on September 13 and continued until September 24. In all, traps were set in 21 different situations, including 13 in the infested area and 8 on adjoining uninfested ground. Small mammals, chiefly rodents, were caught and examined microscopically in the laboratory as follows:

September 13	4	September 18	2	September 23	1
September 15	3	September 19	1	September 24	1
September 16	1	September 20	1		
September 17	2	September 22	1		

In all, 17 small mammals were caught, all within 11 days. Among those obtained the following were determined by Dr. Ned Dearborn, of the Bureau of Biological Survey: House mouse (*Mus musculus*); common meadow mouse (*Microtus pennsylvanicus*); short-tailed shrew (*Blarina brevicauda*).

Not only were the skins of these mammals examined carefully, but the ears and some of the other parts were removed and washed violently in alcohol and the washings examined. As a result of these examinations not a single chigger was found.

This examination of the small mammals of the infested area, it should be noted, was made late in the season. It is possible that if the trapping had been done earlier, different results would have been obtained. During the summer of 1921 such trappings are planned for the months of June and July. It will be interesting to observe the results.

Among other hosts held under suspicion were reptiles. Tortoises were found in the vicinity of the infested area. These were caught and examined, but no chigger larvæ were found. Early in July, 1920, Mr. William Palmer, of the National Museum, captured a large king snake, *Lampropeltis getulus getulus*, at Chesapeake Beach, Md., that had hundreds of mite larvæ attached to its skin, between the scales. He brought the snake to the Museum, and when it was shown to the writer a few days later it had molted. In the cast skin were found hundreds of trombidiid larvæ in various stages of engorgement. An examination of these showed them to be no other than the chigger that attacks man along the Atlantic slope. Parts of the cast skin with chiggers attached were placed in breeding cells, and chiggers that appeared fully engorged were likewise placed in breeding cells, but in neither case did any of the larvæ transform into nymphs. Those attached to the skin of the snake remained attached and soon died unless forcibly removed. The actions of the chiggers in remaining attached to the skin after the latter was cast and their dying in this attached position would seem to show that the king snake is not a natural host. Further, it is known that chiggers exist in enormous numbers where very few snakes of any kind are found.

FIG. 2.—Right chelicera of a chigger-mite larva from the inside, X 1,200. Drawing made from specimen taken at Lake Minnetonka, Minn., and belonging to the University of Minnesota collection.

The determination of the natural hosts of our American chiggers has not been made. Further investigation along this line is needed.

INJURY.

CHIGGER INJURY CONFUSED WITH MANY OTHER KINDS OF INJURY.

Of the many complaints about chiggers that have come to the writer, a very large number, fully one-half in certain sections, were found upon investigation to be due to hives, caused by the disagreement of some food eaten and probably accentuated by hot weather. A very large number of complaints supposed to be concerning chigger attacks were found to be due to nettling from some thorned plant. Serious attacks in a front lawn in Virginia, reported to be

due to chiggers, were found to be due to *Hyletastes missouriensis* Ewing, a gamasid mite, the habits of which are not well known.

Injury from fleas is very similar to the first-stage injury of chiggers, and since fleas soon leave their hosts and chiggers are so small that they frequently are overlooked, flea injury is mistaken for chigger injury. A careful examination with a hand lens will enable one to see the attached chiggers and prevent confusion of flea injury with an attack by chiggers.

DO CHIGGERS PENETRATE THE SKIN?

Both among entomologists and the public generally there is a belief that chiggers burrow into the skin. C. V. Riley (*10*) states in regard to his *irritans* that "This mite is able to bury itself completely in the flesh." In speaking of the same chigger, Osborn (*8*, *p. 252*) sys: "It is brushed from the leaves of various plants onto the hands or clothing of people and to the bodies of other animals, and the mite then proceeds to burrow into the skin."

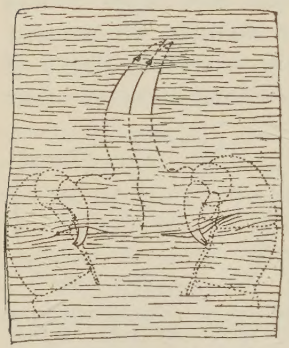

FIG. 3.—View showing the method of attachment of a chigger (northeastern species). Drawing of a part of a "slice" of skin, made from the underside while the larva was attached.

To find out whether chiggers penetrate the skin or not, and also to observe their injury, resort was made to experimentation. On July 15, 1919, the writer exposed the left calf and ankle to chigger attack, and after the mites had settled numbered 10 individuals by writing on the flesh near the mite with ink. Daily observations were made on these chiggers, using low and high power lenses, for the next eight days. It was observed on the first day that the mites attached only by their mouthparts and in no way burrowed into the skin. Observations on the second day showed no change; in fact, after once attaching to the skin by their mouthparts the larvæ became quiescent and did not change their position until they dropped off.

By means of a razor blade several individuals were removed by slicing off a small area of the epidermis around them. When this "slice" of epidermis was examined under a high-power microscope objective it showed the attachment as represented in figure 3. The hooked and ventrally barbed chelicerae were thrust into the epidermis only, and the palpal claws were found forced downward and backward into the epidermis. After both the chelicerae and the palpi have been inserted in this fashion they hold the larva locked, as it were, to the skin. This was made evident by watch-

ing the actions of larvæ with high-power objectives after they had been removed with a "slice" of epidermis. They wriggled first one way, then another, pulled with all their strength backward and forward, gave side twists, and in fact strained in almost every possible way until released. One individual was timed during this process, and it took it seven minutes to free itself from the hold it had obtained on the epidermis.

These observations were repeated upon a lot of 16 individuals for nine successive days. They were numbered as before, and daily observations made upon them. Not only did none of these larvæ burrow into the skin, but they remained attached only by their mouthparts and engorged like ticks. Later they released this hold and fell off.

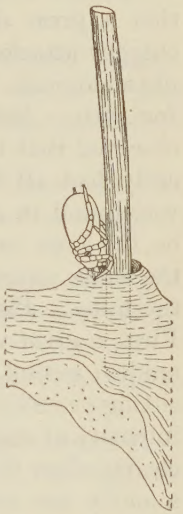

FIG. 4.—"Slice" of epidermis from the skin of calf of leg showing method of attachment of eastern chigger in mouth of hair follicle.

DO CHIGGERS ENTER THE PORES OF THE SKIN?

Some authorities, while not believing that chiggers burrow into the skin, yet hold that because of their minute size they enter the pores and thereby cause much inflammation and other injury. This point has been carefully investigated. Of the 26 numbered individuals that were observed and studied daily, 21 were attached to the smooth surface of the skin, while 5 were attached at the bases of hairs, each having the capitulum thrust into the mouth of the hair follicle as shown in figure 4. Not a single one had penetrated a pore or hair follicle.

The species occurring in the northeastern part of the United States shows a tendency to attach at the mouth of hair follicles. It may be that the larvæ actually try to enter. They are prevented, however, from doing so under normal conditions of the skin by the small diameter of the follicles themselves. For this same reason it would be impossible for chiggers to enter the pores of the skin, unless the latter were greatly dilated as a result of some skin trouble. In diameter the pores of the skin range from 20 to 50 μ, according to Piersol. The width of an unengorged larva from either the western or eastern part of this country is approximately 150 μ. Thus it is seen that unless the pores were unusually dilated the mites could not enter if they would.

In the case of persons who have just cleaned out the pores of the skin after a long period of negligence, it would be possible for the mites to enter some of them, as, for example, pores dilated by comedones. The writer has observed such pores dilated until they were

fully 400 or 500μ in diameter. These pores, however, are most frequently on the face or neck—regions seldom attacked by chiggers. In all the observations made, including many hundred, of chigger attacks, it has always been possible during the early stage of attack to locate the chiggers themselves or their evident places of attachment, and this has always been on the surface of the skin or in the mouths of hair follicles.

DIFFERENCE IN SUSCEPTIBILITY.

Another common belief among the public and entomologists is that a great difference exists between persons in susceptibility to chigger attacks. Such a difference usually has been assumed to be physiological. Observations were made to ascertain the foundation for such a belief, if any existed. Upon several occasions it was observed that there was a difference in injury to people who apparently had all been exposed equally to the attacks of chiggers. It was found in most cases, however, that although all members went on the same picnic, or collected berries in the same patch, or made the same journey, they were not equally exposed to the attacks of the mites. Particularly three fundamental differences were found: First, a great variation in the clothing, especially about the feet and ankles; second, a variation in the actions of the persons, some never sitting or reclining on the ground; and third, a great variation in the intensity of chigger infestation even over a small area. Observations clearly show that these are usually the reasons why some members of a party are but slightly attacked while others are driven almost frantic.

Laboratory tests show that chiggers attack by preference where the skin is very thin and the flesh wrinkled or tender. Field observations also have brought out the fact that women and children suffer more from a given number of chiggers than men do. In other words, a correlation exists between thin skins and seriousness of chigger attacks. This, however, is the only way in which certain differences in the seriousness of chigger attacks between individuals equally exposed could be explained. Although hundreds of people were found susceptible to chigger attacks, no one was found who was clearly shown to be immune.

LOCAL INJURY.

Since there has been so much confusion in regard to chigger injury, a careful tabulation was made daily in the case of two lots of infestations. The first lot of 10 individuals, located on various parts of the leg below the knee, were numbered and notes made daily upon the appearance of the local area around each point of attachment, with the following results:

Attachment of chiggers followed irregularly within a few hours after exposure. The itching which appeared during the latter part of the first 24 hours following attachment grew in intensity. At 24 hours after attachment not a single papule had appeared at any one of the 10 points of attachment. During the second day swelling subsided, and the pinkish coloration around the puncture points was followed, first by a light blood-red and later by a deep blood-red color. The immediate area around each larva changed to a whitish color, and the discolored area as a whole was large and in some cases mottled with light and dark red. The itching sensation reached its maximum the second day.

During the third day after infestation most of the spots changed from the pinkish or light blood red of the second day to a dark blood-red or purplish red. At the end of the third day one-half of the larvæ had become detached.

During the fourth day few changes were noticed. One more larva had dropped off, and a few of the spots were observed to be lighter in color than the day before.

During the fifth day all the remaining larvæ dropped off. Spots retained most of their color and in four instances small water blisters developed near the center of discolored spots.

On the sixth day the color of the spots continued to fade and in one instance was practically lost.

During the seventh day several of the spots regained almost their normal flesh color. Five water blisters were observed, but only one was conspicuous.

On the eighth day the discoloration had entirely disappeared in one instance and almost so in two others. Two water blisters were left.[3]

GENERAL DISTURBANCES.

As has been known for many years, general disturbances frequently follow serious attacks from chiggers. Among the most serious of these is the development of a fever and a temporary upsetting of certain nervous responses. Oudemans has recently called attention (*11, p. 10*) to the narrative of Alfred Russel Wallace relative to the latter's experience with chiggers in the Malay Archipelago. This eminent naturalist wrote:

> All the time I had been in Ceram I had suffered much from the irritating bites of an invisible acarus, which is worse than mosquitoes, ants, and every other pest, because it is impossible to guard against them. This last journey in the forest left me covered from head to foot with inflamed lumps, which after my return to Amboyna, produced a serious disease, confining me to the house for nearly two months * * *.

[3] The appearance of these water blisters is well illustrated by Riley and Johannsen (*11, fig. 43*).

In this country Prof. Herrick (*4, p. 317–325*) has made observations on chiggers in various parts of the United States. He says:

> Very often a slight fever accompanies the eruptions and the patient is liable to lose sleep and suffer almost unbearable torture.

In regard to the general disturbances caused chickens the same authority states (*5, p. 258–260*):

> The chicks seem to contract a diarrhea, grow weaker and weaker, and finally die.

Where the attacks from chiggers are slight, as a rule, no general symptoms are produced. When there is a sudden attachment of several hundred larvæ general symptoms may result. The irritation produced by such a large number may prevent sleep for several nights in succession and thereby upset or disturb digestion. Also, a peculiar nervous disturbance may be caused. This may be brought about by toxins injected by the larvæ or by some other cause.

During the months of July, August, and September, 1919, the writer on many occasions was attacked by chiggers. Some of these attacks were severe and on more than one occasion blood-red spots larger than a half dollar were left. As a result of these repeated attacks a peculiar nervous effect was produced. During parts of the day a feeling of lethargy was noticed, yet to many things a hypersensitiveness was produced. This irritable state became so pronounced at times as to make productive work all but impossible. With this upsetting of the nerves, interference of bodily processes was observed to a considerable extent. It was only after the cool days of November that a normal condition was restored.

RELATION TO DISEASE.

Until the work was begun in Japan on the cause of flood or river fever ("tsutsugamushi-krankheit") some 15 years ago, chiggers had enjoyed an almost complete freedom from suspicion as actual disease carriers. As the work on this deadly disease progressed, however, they were soon held to be implicated in some way and finally shown to be the active carriers of the virus of this disease.

The results of various Japanese workers show that this disease is caused by a nonfilterable virus which is transmitted by means of the chigger bites to man. The natural reservoir is apparently the normal hosts of the chiggers, chiefly field mice, as only a small percentage of the larvæ are infected. Kitashima and Miyajima (*7, p. 232*) state that while "tsutsugamushi-krankheit" is similar to typhus fever and Rocky Mountain spotted fever in that the virus is nonfilterable and arthropod-borne, yet the disease itself is quite different from either.

River fever is a very deadly disease, as about one-third of all the cases are fatal. The only regions of the country affected are those along the water courses or in lowlands. Various attempts have been

made to discover and work out the development of the causative organism, but to no avail.

Among the various substances that have been employed in medication in connection with the disease the following have been used with negative results: Quinine, iodine, quicksilver, arsenics, and staining preparations. From the beginning to the subsidence of the fever salvarsan and trypan red have been used with very poor results. An attempt has been made experimentally to utilize a serum for the disease, but without results.

As chiggers are parasitic only in their larva stage and do not change hosts, it appears that the causative organisms must be transmitted from larva to nymph, to adult, thence to egg and to larva again. Such a development, although a little unusual, already has a near parallel in the case of the protozoan *Piroplasma bigeminum*, the organism of Texas fever, which is transmitted from mother to egg to larva or to nymph, in its alternate host, the North American fever tick, *Margaropus annulatus* Say.

In view of what is already known in regard to the transmission of river fever, the biology of the chigger mites, and the general symptoms following their serious attacks on man and domestic animals, the writer now predicts that in the next 50 years other serious diseases will be shown to be transmitted by these acarids. Should these mites become the transmitters of fatal diseases of domestic animals on a large scale it would be found that the protection of cattle or sheep from them would present a very difficult problem, as the mites are so minute and so widely distributed in woodlands and along water courses.

CONTROL.

In the case of man much protection can be had from chigger attacks by properly clothing the lower extremities or by the application of repellents either directly on the skin or on the under garments.

PROTECTION AGAINST CHIGGER ATTACK.

Since the unengorged larvæ are not over 150μ in width, it is seen that they can pass through the mesh of many kinds of garments; it is easy, however, to wear those of a weave tight enough to prohibit the larvæ from passing directly through the cloth. The employment of tightly woven cloth, or other materials which are impervious to the larvæ, nevertheless, is not enough. These garments must be worn so as to fit tightly around the edges or the larvæ will yet have an avenue of entry.

It was frequently noticed that half-shoes exposed the ankles, and for that matter indirectly the whole body, to much more serious

[4] The control of chiggers affecting poultry is considered in Farmers' Bulletin 801. The measures given in the present bulletin have reference more particularly to chiggers as parasites of man.

attacks than topped shoes. This the writer demonstrated himself many times. High-top shoes or, better yet, laced boots, gave a considerable amount of protection. On several occasions the writer was accompanied on his trips by Mr. W. W. Diehl, of the Bureau of Plant Industry. Mr. Diehl demonstrated well how the body could be protected by wearing topped shoes and spiral puttees. The latter were wrapped tightly about the calves and gave almost complete protection.

Concerning this method, however, there are two objections: First, it causes a considerable discomfort to wear such tight and rather heavy clothing during the hot season, and second, if the individual sits down, reclines, or brings the hands in frequent contact with the surface of the ground, the chiggers will attack in considerable numbers.

Another method of gaining protection which has been tried in the past is to use some repellent on the skin or on the clothing. Sulphur has long been recommended for this purpose and Dr. Chittenden (*2, p. 5*) calls it "a sovereign remedy for mites." A test of its efficacy was made as follows:

At East Falls Church, Va., on July 25, 1919, before going into a well-known infested area, the left stocking and the lower part of the underwear on the left leg were dusted inside and out with flowers of sulphur. The sulphur was applied by the "pinch method," followed by rubbing. About a tablespoonful was used. From 2.30 p. m. to 4.20 p. m. there was exposure to attack in the infested area, and at the end of this time a laboratory examination was made. On the calf and ankle of the untreated leg several chiggers were observed, all unattached and running about very energetically. On the calf and ankle of the sulphured leg not a single chigger was found. Later, at 9.45 p. m., another examination was made. The untreated leg had a large number of chiggers attached, these being distributed from the ankle to the hip. The treated leg did not have a single chigger attached.

On August 4, 1919, a test was made to see if a dusting of sulphur on both sides of the clothing was any more efficacious than dusting on one side only. The stocking and underwear below the knee on the left leg were sulphured by the "pinch method," both inside and out. The stocking and underwear below the knee on the right side were sulphured as before, but only on the outside.

At 3.30 p. m., after exposure, an examination of both legs failed to reveal a single chigger. It was noticed also that there was much more sulphur adhering to the left leg than to the right. A later examination at 11.30 a. m. the next day failed to reveal a single chigger on the left leg and only one chigger wheal on the right, this being near the instep of the foot.

It would appear from this that the dusting with sulphur inside the hosiery and underwear is sufficient if it is so applied as to be well distributed. Later tests fully demonstrated that a single application was sufficient if well distributed.

The "pinch method," i. e., applying a powder insecticide by picking up small amounts with the thumb and fore finger, while well adapted for dusting lousy chickens, for example, was observed to be both tedious and wasteful, hence other methods were resorted to.

Application by means of a talcum shaker was made on August 9, 1919, followed by exposure at Vienna, Va. Examination that night showed it to be 100 per cent effective.

On August 15, 1920, application was made with a pepper shaker. A considerable tendency of the sulphur to clog the small holes of the top was noticed, but by violent agitation a fairly even application was made. Only the inside of the stockings and the lower part of the underwear were treated. Exposure for about 3 hours was made in the woods north of Chesapeake Beach, Md. Later examination showed 100 per cent efficiency. It should be added that if sulphur is dusted by means of a salt or pepper shaker, after the operation all unused sulphur should be removed and the container washed. This will prevent the tarnishing of the metal parts of the shaker.

Mr. Flint, of the State Natural History Survey of Illinois, states that he has applied sulphur by means of a small bag and also by the "pinch method," with good results. Dr. J. W. Folsom also reports good results from sulphur treatment by the "pinch method." During the summers of both 1919 and 1920 several members of the bureau staff tried the use of sulphur, and in every case good results were reported and usually complete protection.

DESTRUCTION OF BREEDING PLACES.

It is hoped that the observations made on the habits and local distribution will enable much more to be done to advantage in destroying the breeding places of chiggers. Especially is this method of attack to be recommended about private dwellings and in poorly kept public parks and at summer resorts. Already its feasibility has been demonstrated. In and around Washington many chigger-infested lots or fields have been automatically rendered free of chiggers by turning these to cultivation or cleaning away the rough growth. Prof. F. L. Washburn (*12*) has the following to say in regard to the effect of cutting down bushy growth in Minnesota:

> Capt. Zimmerman, living on Enchantment Island, Lake Minnetonka, having found this pest troublesome on his own island and upon the neighboring Phelps Island, has reduced their numbers materially by cutting out much underbrush, thus letting in the sunlight.

A well-known golf course was laid out west of the District of Columbia in a region heavily infested with chiggers. Later an investigation showed that the sodded areas where the balls were played were quite free from chiggers. When persons went into the patches of rough growth between or around these areas they were attacked by chiggers.

A chigger-infested lot in East Falls Church, Va., was cleared of rough growth and a house put on it during the summer of 1919. These operations destroyed the breeding places of the chiggers.

Of all the growths that favor the harboring of chiggers none is more favorable than wild blackberries or wild dewberries. Wild blackberry patches in Virginia and Maryland invariably were found to harbor immense numbers of chiggers. Where such patches are located at very objectionable places their obliteration would seem justified. The fruit produced by these wild canes is of a good quality, however, and constitutes not a small item in the summer food supply of the country; hence a wholesale destruction of wild blackberries would be both rash and foolish.

Dr. Chittenden has mentioned (*2*) the value of cattle and even of the passing of many persons in destroying chiggers. In 1914 (*3*) he published the results of a conversation which he had with Mr. William N. Irwin (through an error given as E. F. Erwin), who before his death was connected with the Department of Agriculture; in this conversation Mr. Irwin stated that he considered cattle inadequate where a large area was to be dealt with. He claimed, however, that he had experienced good results where sheep were used instead of cattle. The efficacy of sheep in chigger eradication thus being shown, an explanation of their agency and its effect on the chiggers is due. Dr. Chittenden claimed that the value of cattle in chigger control came from the trampling of the pests, and he would explain in the same way the benefits from the utilization of sheep, adding, however, that the sheep are probably more effective, by "keeping the grass more tightly cut than would cattle." Mr. Irwin explained the agency of the sheep as being due in part to the ascent of their legs by the chiggers and their destruction through contact with the oil in their wool. The present writer would explain this observed difference between the efficacy of cattle and sheep as being due chiefly to the food habits of the latter, the sheep not only keeping the grass more closely cropped, but also feeding to a considerable extent on the leaves of shrubbery.

Just what the value of a certain amount of shrubbery is to chiggers is not known in the case of our species. It may furnish a favorable environment for the natural hosts of the parasites, or furnish the necessary environment for either the nymphs or adults of the chiggers, or both these instars, or furnish a proper environment for the larvæ.

It has been stated that the cropping or mowing of grass lets in more sunshine and in this manner destroys the chiggers. This can hardly be the case, however, as larvæ have been handled and exposed frequently in the bright sunshine and no ill effects to them noted. In the field also, where there is only a scant growth of dewberries and an abundance of sunshine chiggers may be found in great numbers.

Chiggers are almost semiaquatic and will endure frequent submergence. In the laboratory they do well, if not their best, in an atmosphere near saturation. This humidity requirement will help explain the advantage of a rough growth to the species, which lives almost exclusively at the surface of the ground. In most situations it may be that the moisture is only sufficient when the ground is clothed with a considerable growth of vegetation. Thus the effect of sunshine would appear to be indirect and to destroy the chiggers in most situations where allowed to act by drying the surface of the ground.

DESTRUCTION OF THE CHIGGERS THEMSELVES.

It is stated that chiggers may be destroyed by a liberal application of sulphur to the field. The use of 50 pounds to the acre has been recommended. For this purpose a dust gun or dust blower could be used to advantage. On lawns the use of sulphur is unnecessary, as chiggers will automatically disappear if the grass is kept cut short.

Chiggers may best be destroyed on the body of man before they become attached or very soon afterwards. If one knows that there has been exposure to chigger attacks the shins and ankles should be examined with a hand lens for the active larvæ even before any itching sensation is felt. Only a few of the active larvæ will be observed. They will be seen to run over the skin very rapidly and can not be captured to advantage.

Larvæ on the body can be easily killed by the application of an acaricide. Various substances applied at the time of bathing have been recommended. On August 10, 1919, after exposure to chigger attacks, a thick lather of soap was applied to the affected parts. The lather was allowed to remain for 10 minutes and was worked continually over the skin. After 10 minutes it was washed off. Examination next day failed to reveal any chiggers and no itching developed.

On August 18, 1919, after exposure at Somerset, Md., and after larvæ had attached, the same application of thick soap lather was tried. On the 19th much itching was felt, yet no chiggers were found. Apparently the soap had acted as an acaricide but not as a palliative.

Dr. Maurice C. Hall, of the Bureau of Animal Industry, reports excellent results from the use of sulphur ointment against the larvæ after they have become attached.

Commercial alcohol (95 per cent) has been used by several acquaintances and by the writer himself to good advantage against the chiggers attached to the skin. When the free larvæ are immersed in alcohol and observed under the miscroscope they are seen to die in short order, usually in from 1 to 3 minutes. The alcohol is an excellent acaricide and also a good antiseptic for the unabraded or slightly abraded skin, and has a further advantageous effect in hardening the dermis. It should be applied quite freely and the application repeated two or three times.

Any of the lighter oils kill the larvæ quite rapidly, and can be used to advantage against the larvæ if the latter are confined to a small area on the body. Sulphur acts slowly, but if applied with soap and allowed several minutes to act should give good results.

PALLIATIVES.

To those who go little afield and are thus ignorant of some of nature's ways warnings that preventive measures should be taken are usually but little heeded, hence it is necessary to give directions in the use of palliatives—the most unsatisfactory of all measures. Undoubtedly most of the so-called palliatives are of value chiefly, if not entirely, because of their acaricide action or because they act antiseptically, or in both these manners.

In the Panama Canal Zone, according to Dr. W. A. Taylor, Chief of the Bureau of Plant Industry, a saturated solution of salicylic acid in alcohol, with a little olive oil added, has been used to good advantage as a palliative. Both he and Mr. H. H. Bennett, of the Bureau of Soils, used this mixture with very beneficial results in the Canal Zone.

In the Southern States, according to Mr. Bennett, butter or lard with a liberal mixture of table salt, or pure kerosene oil, is frequently used as a palliative. With regard to their benefit he says: "I am still not convinced that they are more than moderately efficacious * * *."

Among the other substances recommended as palliatives are the following: Ammonia, cooking soda, dilute solution of iodine, camphor, and alcohol. Statements made to the effect that an acid toxin is injected by the larvæ are not based on observed fact or experimental demonstration. We do not know even that a toxin is injected by these acarids. As before stated, the intelligent use of palliatives awaits experimentation on the nature of chigger injury from the physiological standpoint.

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